Integrated geophysical study of the Dead Sea rift for hazard assessment, and water and mineral resources

SUMMARY:

The proposed project seeks to collect and integrate two advanced geophysical methods to improve earthquake hazard assessment, aid in mineral and water exploration, and provide subsurface information for large-scale infrastructure projects. These methods, seismic reflection profiles and high-resolution aeromagnetic surveys, can provide the detailed location and geometry of faults, locate dikes in which minerals and ores are found, and map potential aquifers and the basement under the rift valley. Some of the economic needs, which drive this project, are: The expected human and economic losses to Jordan, the West Bank, and Israel should an earthquake, such as the ones that occurred in 1927 near Jericho, and in 1837 north of the Sea of Galilee occur again; Mineral exploration along the Jordanian side of Wadi Araba (Arava), which currently suffers from lack of regional magnetic mapping; And the need for a detailed subsurface structure of Wadi Araba (Arava), the future route of the Dead Sea-Red Sea Canal, and the future site of the joint Jordanian/Israeli international airport north of Aqaba. An equally important goal of the proposed project is to promote close working relationships among Jordanian, Palestinian, and Israeli technicians and scientists and to provide training in seismic techniques for oil, mineral, and water exploration.

INVESTIGATORS:

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DESCRIPTION:

This US-AID project Middle Eastern Regional Cooperation (MERC) project has several objectives: (1) to delineate subsurface sedimentary basins and faults along the Dead Sea Rift to be used in exploration of groundwater, oil, earthquake hazard assessment and infrastructure projects, such as the Dead Sea-Red Sea Canal; (2) to demonstrate the suitability of advanced geophysical methods in this environment; (3) to transfer technology to the various project participants and (4) to promote peace in the Middle East through scientific and economic cooperation.

START DATE OF PROJECT:

October 1, 2002

END DATE OF PROJECT:

September 30, 2006

TOPIC:

Resources and the Environment

APPROACH:

The rift valley represents an important economic province for Jordan and Israel, and is associated with natural hazards that affect the population living in the valley and in the surrounding highlands. No single participant can carry the proposed work alone and expect to produce the benefits predicted from this project. Both Israel and Jordan have collected seismic reflection profiles of varying quality in the rift valley in the past. But the interpretation of these lines was very difficult because the lines were laid out in unfavorable orientations so as not to cross the international border running in the midst of this narrow valley. In this project we will collect seismic lines to image the features of interest rather than laying out the lines to conform to political boundaries. Seismic methods have been used for many years for oil exploration, but they found new use in recent years serving environmental, geotechnical, and hydrological studies. The Geophysical Institute of Israel (GII) has in the last several years been successfully conducting surveys for water resources using seismic reflection methods and has gained considerable experience in the process. The acquisition parameters of these lines will be designed specifically to address the shallow (less than 2.5 km deep) subsurface structure with a maximum nominal resolution of 5 meters (Figure 4). Another benefit to fault mapping, which hitherto was not considered, is the possibility of mineralization zones with ore concentrations along fault planes. Although both Israel and Jordan collected aeromagnetic data in the past, no data were collected in the rift valley itself because of the proximity to the international border. Aeromagnetic survey entails mounting a magnetometer on (or towing it behind) a light aircraft and recording the magnetic field anomalies on board. This method provides an extensive regional coverage in a short period of time relative to overland methods, but because the aircraft is farther from the magnetic sources, the resolution is degraded. Recent advances in navigational capabilities allow the collection of controlled dense grid of flight lines at low altitude that substantially improve the spatial resolution of the magnetic map. A survey, such as proposed here, had not been performed in either country and will, therefore, serve as a good training project for further such work in each country. Finally, a joint interpretation of the seismic, magnetic, and the

gravity data collected during our previous US-AID project will take advantage of joint 3-D inversion techniques, recently developed at the USGS. The seismic data collected in this present project is being used as a basis for a joint University of Texas-USGS-LANL proposal to DOE to compare seismic wave propagation thru different rift valleys around the world.

IMPACT/RESULTS:

The populated areas of Israel, Jordan, and the Palestinian Authority comprise a single geological and geographical unit of the Dead Sea Rift and its uplifted surrounding highlands. The different tectonic, geomorphic, and climatic factors that affected the recent geological history have operated on the entire region without regard to political boundaries. For example, the tectonic plate boundary along which the Arabian and African plates slide, lies along the political boundary between Jordan and Israel. It is the most seismically active region in the Middle East with over 4000 years of documented destructive earthquakes. The ancient Lake Lisan, which flooded the rift valley during part of the last glacial period, covers parts of both countries. Subsurface aquifers in the rift valley are shared by both countries and are recharged by water flowing from the surrounding highlands. The rise of the highlands on which Amman and Jerusalem are located occurred simultaneously due to yet unclear process and may continue at present. Minerals and other natural resources are continuous across the Dead Sea Rift, but with a lateral offset of 105 km due to the recent tectonic activity. It is simply impossible to study the physical environment of one country without having the full cooperation of the other ones. This fact was also recognized by politicians and incorporated into the Peace Treaty between Jordan and Israel. This project is designed to specifically address these aspects that can only be achieved by regional cooperation, as will be detailed. The primary economic benefits of the proposed study will be: 1. Determination of the thickness of young sediments filling the rift valley to assist in the location of oil and water drilling and the estimation of potential oil and water reservoirs. 2. Mapping sediment thickness and subsurface faults to assist in assessing the directions of water flow, in geotechnical studies for the Red Sea - Dead Sea Canal, the proposed joint international airport, and in other large-scale construction projects along the rift valley. 3. Mapping dikes in the crystalline basement to locate potential ore and mineral deposits. 4. Mapping subsurface volcanic intrusions to assess the potential for hydrothermal energy resources and the potential for hydrocarbon maturation. 5. Mapping subsurface faults to assist in earthquake hazard assessment. This problem has become particularly acute following the increased seismic activity in the Gulf of Aqaba. By analogy to Turkey and California, the seismic activity is expected to migrate northward with time. The proposed project builds on the results of a previously funded USAID grant #TA-MOU-96-C15-165. That project was the first successful attempt to address a single geological structure spanning both countries. Scientific results pertaining to economic development include (ten Brink et al., 1998, 1999): (1) The discovery of several new subsurface basins and identification of the shape of other basins. Ground water is stored in aquifers that are located in these subsurface basins. (2) The mapping of faults segments along the Dead Sea plate boundary. Many of the fault traces were unknown or only partially known previously.

PUBLICATIONS:

- Earth and Planetary Science Letters, v. 199, p. 67-79, 2002
- Israel Journal of Earth Sciences, v. 52, p. 113-122, 2003
- Uri S. ten Brink, Abdallah Al-Zoubi, Michael Rybakov, and Yair Rotstein , 2004, INTEGRATED GEOPHYSICAL STUDY OF THE DEAD SEA RIFT FOR HAZARD ASSESSMENT AND MINERAL RESOURCES, Grant No. TA-MOU-01-M21-012, INTERIM SCIENTIFIC REPORT, April 29, 2004, Geophysical Institute of Israel
- Uri S. ten Brink, Abdallah Al-Zoubim Yair Rotstein, Michael Rybakov, and Uri Frieslander , INTEGRATED GEOPHYSICAL STUDY OF THE DEAD SEA RIFT FOR HAZARD ASSESSMENT AND MINERAL RESOURCES, INTERIM SCIENTIFIC REPORT, 2004 No. 2, Grant No. TA-MOU-01-M21-012 , Geophysical Institute of Israel